so as to give a complete analysis of the losses in about half an hour after getting the machines into a steady condition.

We are flattered by the graceful acknowledgment that our mode of numbering the illustrations has been adopted, but we would have greatly preferred that in a much more important direction the author had followed the methods we advocate, but cannot claim to have originated. We refer to the practice of making the algebraic symbols stand for *things* and not merely for numbers, so that the formulas will apply irrespective of units. Mr. Maccall seems unable to discuss principles apart from some particular units, with the result that his mathematics is horribly complicated by numbers which have nothing to do with the facts, but arise from the unfortunate, although perhaps customary, choice of units. In some cases we are treated to separate deductions of formulas for inch and metric measure, instead of one formula with two sets of constants. As we said on a former occasion, the laws of nature were exactly the same ages before man ever discovered anything about them, much less invented units in which to express his measurements concerning them. *Make the symbols stand for things and the units will look after themselves.* Formulas will then represent *facts*, and not merely particular numerical relations.

We like the author's special symbol for "number of turns," but we object to making his other new symbol do double duty by using it both for "current × turns" and for the name of the unit "ampere-turn."

For the new edition, which we confidently expect, we hope that the publishers will adopt a paper suitable for reproducing the half-tone blocks. Fortunately, these form only a small proportion of the illustrations, but where they do occur they entirely spoil the appearance of the book, while at the same time they are seldom sufficiently distinct to be of any real use.

(2) "Single-phase Electric Railways" gives an outline description, with leading data, of all the important lines of this type which have so far been constructed. Although most of the matter has already been published in the columns of the *Engineer*, it is convenient to have it all collected together for ready reference. For that reason, it is unfortunate that the author has decided not to deal fully with the motor itself, and also that he has not included a great deal more data regarding the operating costs, of which much has been made public during the past few years.

The book is abundantly and well illustrated by drawings and photographs; indeed, the latter take such a very prominent place as to almost form the *raison d'être* of the book. The overhead construction is taken in fairly full detail, but the particulars of the motors and controlling gear are somewhat meagre. Diagrams of connections are certainly there, but the written description is generally too slight, except for the expert.

The first chapter of three pages is mainly historical, but just touches on the thorny battle of the systems. More eloquent than all the opinions of the author and the experts is the fact, brought out in a recent number of the *General Electric Review*, that since the advent of the high-voltage continuous-current system, the mileage of single-phase railways has been practically stationary, while that of the continuous-current system has gone up by leaps and bounds, and now far surpasses its rival. It would have been far better if this chapter had given an account of the general principles underlying single-phase railway working, and a closely reasoned account of the difficulties arising from it, the way in which these have been overcome, and the relative advantages and disadvantages of the system. A comparison of the solutions found for these difficulties in the various lines described further on would have served to weld the book into a homogeneous whole, instead of leaving it in twenty-three watertight compartments (one for each line described), with no connection between them but the common title to the whole book.

We may conclude by saying that to the expert and to the student of railway engineering, the book will be of especial value as a work of reference, diminished although that is by the lack of references to other publications. Others may find it interesting, for the style is good and the matter is made as readable as a catalogue (for such it really is) well can be. DAVID ROBERTSON.

THE LIMITATIONS OF SCIENCE.

(1) *The Limitations of Science.* By Prof. L. T. More. Pp. vii + 268. (New York: H. Holt and Co., 1915.) Price $1.50 net.

(2) *The Magic of Experience.* A Contribution to the Theory of Knowledge. By H. Stanley Redgrove. Pp. xv + 111. (London: J. M. Dent and Sons, Ltd., 1915.) Price 2*s*. 6*d*. net.

(1) PROF. MORE has written a study from a conservative point of view of the limitations of science as shown in modern physical views. "Will the results of experiment made objectively which must, however, be interpreted subjectively, fail in their turn as criteria of truth?" (p. 2). "Science, . . . like philosophy, has no ontological value. Should not the men of science clearly recognise this fact, and confine

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their effort to the legitimate function of science—the discovery of natural phenomena and their classification into general laws by logical mathematical processes?" (p. 31).

The account of the growth of the mechanistic view in science and of atomism, and the criticism of them and development of a science of energetics by Rankine, Mach, Duhem, and Ostwald, are fairly adequate, and direct attention to some points—notably in Rankine's attitude—which have been forgotten by most people. It is rather disappointing to find no mention of Stallo's extremely important work in the theory of knowledge, especially when we see that the second chapter is headed "The Metaphysical Tendencies of Modern Physics," and read such passages as that on p. 70. But Prof. More's problem is not quite the same as Stallo's. In Stallo's time physicists vigorously denied that their theories had a metaphysical basis, and it was Stallo's purpose to show that the physicists were mistaken in their denial. But at the present time such a theory as Larmor's has an avowedly philosophical background. The great obligation of modern physics to Descartes is seen from the admirable discussion of Descartes' physical system in chapter iii. "A comparison of his [Descartes'] postulates and conclusions with those of our modern theory shows them to be almost identical, if we change his antiquated knowledge and his discarded metaphysical language into modern terminology" (p. 67; *cf.* pp. 98, 101).

The fourth chapter is a reprint of an article in the *Philosophical Magazine,* and, under the heading "The Scientific Method," contains a very sensible critical review of recent physical theory. Prof. More himself advances a hypothesis to make the ratio e/m agree with the experimental evidence (p. 140). The fifth chapter is on "The Classical and the New Mechanics," and here Prof. More concludes that, if we finally adopt the most modern thesis that matter is the manifestation of energy, we are acknowledging that "the guides to knowledge are now to be found in those subjective impressions which must depend on the individual, and vary with him. . . . The classical natural philosophy of Newton and Galileo has drifted into that transcendental symbolism which is apt to take place when German thinkers become the leaders in philosophy" (p. 163). The sixth chapter is on "Skepticism and Idolatry in Science," and here some of the writings of Poincaré and Sir Oliver Lodge make admirable illustrations; and the seventh chapter is on "Science as the Arbiter of Ethics." This is a thoughtful book, and though easy to read, is not superficial.

(2) Mr. Redgrove's book makes a great point of the fact that experience is subjective, as Berkeley pointed out, and of which Mach has made such illuminating use in physics. Of course materialism becomes easily refutable from this point of view. Mr. Redgrove leans to the mysticism of John Smith the "Cambridge Platonist," Boehme, and Swedenborg, but—and this would surprise some after that—he adopts what seems to be a very sensible attitude in his emphasis on the validity of the laws of nature, and the fallacy of "Christian Science" metaphysics. Mr. Redgrove follows Mill in thinking that mathematical truth is merely founded on experience, and holds that absolute truth is unknown and unknowable. In spite of this we may approach truth, "just as a mathematical series may for ever progress towards some limit which it never reaches" (p. 86). The mathematical illustrations seem to be quite irrelevant: we might just as well illustrate a fanciful doctrine that we can attain the limits of knowledge over and over again in our lives, and yet approach no definite knowledge, by instancing the function sin x as x proceeds to infinity along the real axis.

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RECENT ELECTRICAL BOOKS.

(1) *Arithmetic of Alternating Currents.* By E. H. Crapper. Pp. vii+208. (London: Whittaker and Co., 1915.) Price 2*s.* 6*d.* net.

(2) *Constant-voltage Transmission: a Discussion of the Use of Synchronous Motors for Eliminating Variation in Voltage in Electric Power Systems.* By H. B. Dwight. Pp. vii+115. (New York: J. Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1915.) Price 5*s.* 6*d.* net.

(3) *Alternating-current Work: an Introductory Book for Engineers and Students.* By W. P. Maycock. Pp. xxiii+415. (London: Whittaker and Co., 1915.) Price 6*s.* net.

(4) *Experimental Electricity and Magnetism.* By M. Finn. Pp. x+436. (London: G. Bell and Sons, Ltd., 1915.) Price 4*s.* 6*d.*

(1) PROF. E. H. CRAPPER'S book can be recommended to all desiring to obtain a thorough working knowledge of the everyday calculations which have to be made by alternating-current engineers. The lengthy experience the author has had in training electrical engineers has convinced him that the only way to master the subject is to acquire facility in solving the types of numerical problems which occur in practice. There are 232 examples in the book. The answers to all of them are given, and fifty are worked out in full. They are arranged in order of difficulty, and none of them make excessive demands on the

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